Sensorization and Optimization of Industrial Graphic Arts Machinery Using Artificial Intelligence Techniques

Angel Luis Garrido
University of Zaragoza
Henneo Media
Zaragoza, Spain
Email: garrido@unizar.es

Jonathan Rodríguez
Technical Office Manager
Henneo Print
Zaragoza, Spain
Email: jonathan.rodriguez@henneoprint.com

Mariano Sánchez
Maintenance Head
Henneo Print
Zaragoza, Spain
Email: msanchez@henneoprint.com

José Manuel Antón
Production Manager
Henneo Print
Zaragoza, Spain
Email: jmanton@henneoprint.com

Roberto Castán
Development Department
Hiberus Tech.
Zaragoza, Spain
Email: rcastan@hiberus.com

Susana Sangiao
Development Department
Hiberus Tech.
Zaragoza, Spain
Email: ssangiao@hiberus.com

Carlos Bobed
IIS Department
I3A, University of Zaragoza
Zaragoza, Spain
Email: cbobed@unizar.es

Eduardo Mena
IIS Department
I3A, University of Zaragoza
Zaragoza, Spain
Email: emena@unizar.es

***Abstract*—Today, manufacturing companies have technologies that allow them to monitor the different processes carried out in their facilities. These technologies, based on Real-Time Operating Systems and Internet of Things paradigms, are mature, and their application is widespread in different sectors. The problems come when factories own old machinery and legacy systems, and when the processes are poorly automated, which is a typical scenario in the graphic arts industry. To solve this situation, we propose a comprehensive management framework that obtains real-time information through Sensing systems and Artificial Intelligence technologies. The advantages obtained are the unification of information, the simplification of obtaining information by different departments, the automation of processes, and the support in planning tasks. We are currently testing our proposal in a real environment with promising results.**

***Keywords*-Sensors; Knowledge-Based Systems; Internet of Things; Machine Learning.**

I. INTRODUCTION

Nowadays, manufacturing companies have technology that allows them to monitor the processes performed in their facilities. These technologies, based on Real-Time Operating Systems (RTOS) and Internet of Things (IoT) paradigms, are in a mature state, and their use is already being normalised by factories from diverse sectors [1]. The problems come when a series of circumstances occur, such as those listed below:

- Factories with old machinery.
- Machines and information systems without connection among them in the same manufacturing tasks.
- Presence of manual and little automated processes.

In those cases, when it is necessary to modernise the production systems, there is no choice but to carry out retrofitting work [2], which involves the replacement of existing parts or the incorporation of new ones to improve the characteristics of the machine or device. Ontologies and knowledge bases are often found in the literature as common resources for integrating legacy industrial systems with current systems [3] [4]. Still, as far as we know, there are no application studies in the graphic arts sector.

Precisely, if we focus on the graphic arts sector, in the specific scenario of printing publications with large rotary machines, the three situations mentioned above usually come together [5]. The life cycles of the machinery are very long, so it is easy to find rotary presses that are 20 years old or more, in perfect operation, logically dragging with them old computer systems that are complex to interconnect with current systems. The disadvantage is that the electronic and computer systems are based on legacy systems, and when they were manufactured, the RTOS and IoT paradigms were barely developed. Furthermore, many of the processes in these factories are still semi-automated, or even manual.

To work in this environment, we propose a comprehensive management framework that obtains information in real-time from both the old machinery and the legacy systems, through sensorization techniques and Artificial Intelligence (AI) technologies such as semantics management tools and machine learning. We are currently testing our proposal in collaboration with Henneo Print [6], a significant company in Spain devoted to printing all kinds of publications. The rest of this paper is organized as follows. Section II describes the graphic arts working context. Section III depicts the proposed architecture, and finally, Section IV addresses the conclusions and future work.

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II. Graphic Arts context

There are two types of technologies when printing publications with large rotary presses: the so-called "coldset" (with cold ink) and the so-called "heatset" (hot ink, because a press-dryer intervenes in the process). The coldset technology is used to print newspapers, and heatset is used to print leaflets, books, and magazines, products that require a higher quality.

In the coldset stage, job planning is relatively simple, since publications generally have a fixed periodicity (daily, weekly, monthly, etc.) and very stable delivery windows. But, in the heatset stage, planning is fully variable as it is specified by customers. So, any delay entails a critical modification of the factory's global planning. It is a much more dynamic and unstable work environment, and many factors come into play, so decision-making becomes complicated, and tools are necessary to assist managers in their daily work, both in terms of machine maintenance and production planning.

Therefore, today's challenge in this sector is to computerise heatset processes at printing plants by incorporating RTOS and IoT technologies on old machinery and systems. In other words, we need suitable information to assist complex tasks such as planning tasks or maintenance reporting.

III. Architecture

In Fig. 1, we can see the different elements of the proposed architecture and the relations among them:

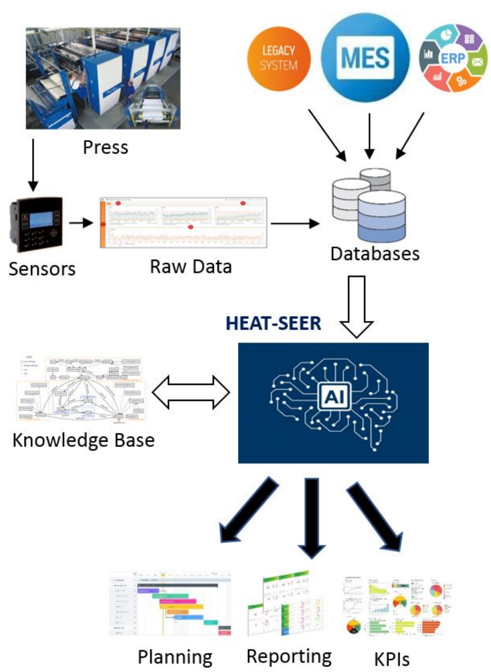

Figure 1. Overview of the proposed architecture.

Through retrofitting techniques and incorporating specific sensors, raw information is obtained from different aspects of the press: speed, temperature, electrical consumption, etc. At the same time, the most relevant information from the other systems existing in the factory has been considered: the Manufacturing Enterprise System (MES), the Enterprise Resource Planning (ERP), and specific systems, which, in most cases, are legacy systems. All the data stored on those systems are collected from their respective databases by *"Heat-Seer"*, an AI system, which, guided by the historical information and business rules contained in a specific knowledge base, is capable of performing the following tasks:

1) To assist the technical office in its planning tasks, simulating different production scenarios. It uses business rules and information obtained through machine learning from historical production data.
2) To automate data collection tasks and reporting for the production and maintenance departments.
3) To show *Key Performance Indicators* (KPI), the critical quantifiable indicators of progress toward an intended result. In this case, business results.

After passing the sensorization and information collection phase, the architecture implementation and testing work is underway, along with the development of the AI tool.

IV. Conclusions and Future Work

The contribution of this work is to propose a methodology for the problem of optimizing production tasks such as reporting, planning or maintenance when using legacy systems and machinery in the graphic arts sector. The advantages obtained will be the unification of information that allows data exploitation by different departments, the automation of processes, and the creation of new tools that will enable, for example, the planning and simulation of varying manufacturing scenarios. In future work, we have planned to integrate the knowledge base with a conversational system that allows operators to resolve doubts regarding work procedures using natural language.

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